Decision support through knowledge management: the role of the artificial intelligence

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Abstract
Knowledge management (KM) has recently received considerable attention in the computer information systems community and is continuously gaining interest by industry, enterprises and government. Decision support and KM processes are interdependent activities in many organizations. In all cases, decision makers always combine different types of data and knowledge available in various forms in the organization. One of the key – but also criticized – building blocks for advancing this field of knowledge management and consequently supporting the decision making is artificial intelligence (AI). In this framework, this paper aims to improve understanding of AI towards knowledge management. It examines and discusses both the potential and the limitations of basic AI technologies in terms of their capability to support the KM process and shares thoughts and estimations on further research on the development of the next generation decision support environments.

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1 Introduction

Globalization has placed businesses everywhere in new and different competitive situations where knowledgeable and effective behavior has come to provide the competitive edge. Nowadays, many organizations try to improve their competitive position through better use of knowledge, looking for new ways to harness and enhance the expertise and intellectual capital they possess, while aiming to continuously leverage them into new applied knowledge (Nonaka, 1991; Wiig, 1993; 1997; Wilkins *et al.*, 1997; Davenport and Prusak, 1998a). On the other hand, taking into consideration that organizations and enterprises are now becoming increasingly complex and sometimes multinational, decision-making is becoming more and more complicated, difficult and risky and KM more necessary.

In general, there is an agreement that the knowledge-based economy has arrived and that those organizations which will succeed in the global information society are those that can identify, value, create and evolve their knowledge assets. Many researchers (Senge, 1990; Drucker, 1993; Galagan, 1997; Leonard, 1999) have described knowledge, rather than capital or labor, as the only meaningful economic resource in the knowledge society. The success of an enterprise depends on the interplay of many factors. Some are beyond influence or control by the enterprise while others are associated with the strategic moves that the leader pursues. Among these factors we find (Wiig, 1999):

- the ability to deliver desired service paradigms by individuals, departments and business units, and by the overall enterprise;
- the capability of employees to deliver the workproducts for which they are responsible;
- the effectiveness of interpersonal work (teaming and networking) through coordination, cooperation and collaboration;
- the degree to which innovations occur, are captured, communicated and applied; and
- the effectiveness of enterprise systems, procedures and policies.

All of the factors depend to significant degrees on effective availability and application of good knowledge.

At this point, the key question that arises is the following: "What are the technologies and techniques to be employed in knowledge management?" In this article, we explore the extent to which artificial intelligence can support enterprises in their attempts to manage knowledge in a successful way, with the frameworks briefly outlined above. AI has received considerable attention during the last two decades and has been widely applied in many scientific areas, so it is surely interesting and necessary to understand the potential and the limitations of basic AI technologies in terms of their capability to support the KM process.

2. Main issues in knowledge management

Before analyzing some key issues in KM, we should firstly make a clear distinction between data, information, and knowledge. In general, data are considered as raw facts,

while information is regarded as an organized set of data. Knowledge is perceived as meaningful information; or the understanding, awareness, familiarity acquired through study, investigation, observation or experience over the course of time (Merlyn and Valikangas, 1998; Zeleny, 2000; Bollinger and Smith, 2001). It is an individual's interpretation of information based on personal experiences, skills and competencies. Wisdom is acquired as an individual gains new knowledge through the transformation of collective experiences and expertise. A model of this process is illustrated in Figure 1.

According to Davenport *et al.* (1998) knowledge management is defined as follows:

> Knowledge management is concerned with the exploitation and development of the knowledge assets of an organization with a view to furthering the organisation's objectives. The knowledge to be managed includes both explicit, documented knowledge, and tacit, subjective knowledge ...

Other authors have sought to take a process, rather than project, based perspective to the definition of KM. Liebowitz (2000) presented a nine-step approach to KM:

1 Transform information into knowledge.
2 Identify and verify knowledge.
3 Capture and secure knowledge.
4 Organize knowledge.
5 Retrieve and apply knowledge.
6 Combine knowledge.
7 Create knowledge.
8 Learn knowledge.
9 Distribute/sell knowledge.

In general, one of the most important issues in KM is the organization, distribution and refinement of knowledge. Knowledge can be generated by data mining tools, can be acquired from third parties, or can be refined and refreshed. The collected knowledge can then be organized by indexing the knowledge elements, filtering based on content and establishing linkages and relationships among the elements. Then this knowledge is integrated into a knowledge base and distributed to the decision support applications. The insights resulting from the decision support applications are used to refine the existing knowledge and feedback into knowledge organization. Figure 2 presents graphically the whole process.

Another important issue is the knowledge presentation. This refers to the ways knowledge is displayed to the organizational members. In general, an organization may devise different procedures to format its knowledge base. Because of the different presentation styles, organizational members often find it difficult to reconfigure, recombine and integrate knowledge from distinct and disparate sources.

A third key point is knowledge distribution and sharing. We should always keep in mind that when knowledge within the organization is shared, it becomes cumulative. Information technology and the Internet have enabled and increased this sharing of knowledge and new, emerging technologies can further advance it.

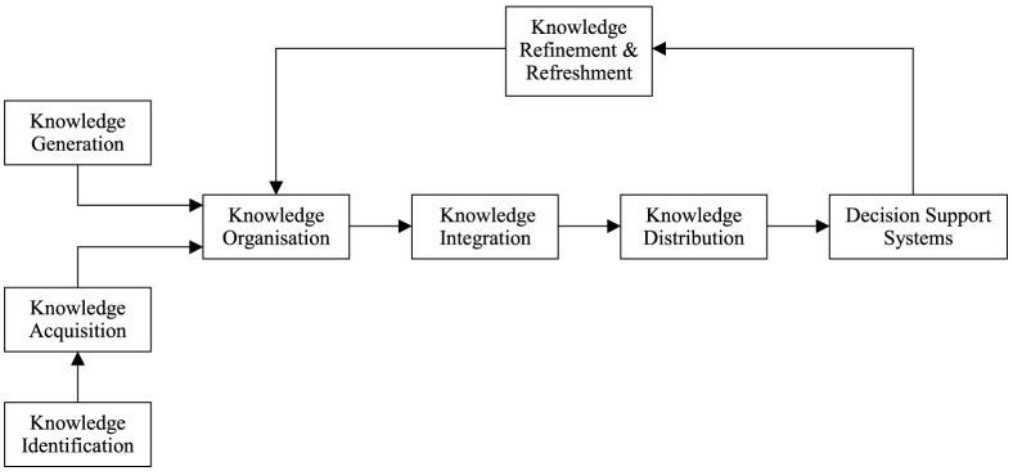
Concluding, we have to stress the fact that KM – in any case – implies recognition of the different ways in which the same piece of knowledge can be used, depending on the context and transformation processes involved in satisfying goals and achieving knowledge outputs from information inputs. Most of the emphasis in the literature so far has been on KM frameworks, approaches (Nonaka, 1994; Holsapple and Joshi, 1997; Wiig *et al.*, 1997; Basu, 1998; Rubenstein-Montano *et al.*, 2001; Bolloju *et al.*, 2002) and not on KM systems and technologies. In the following section, the authors deal with the role the artificial intelligence can play in KM and address the question as to which extent AI can provide good solutions in order to improve KM effectiveness and efficiency.

3 The role of artificial intelligence in knowledge management

The KM software market is exhibiting strong growth as more companies begin to understand how to apply KM practices for the improvement of enterprise value. The technologies used to support KM initiatives are evolving rapidly with new vendors entering as others leave (IDC, 2002). Of particular interest within the framework of technology's role in KM is the role of AI in its various forms. AI has received considerable attention during the last two decades and has been widely applied in many business areas (Mentzer and Gandhi, 1993; Tafti and Nikbakht, 1993; Liebowitz, 1997; Zhang *et al.*,

Figure 1
Stages of learning evolution

Figure 2
Stages of knowledge processing



1998; Metaxiotis and Samoulidis, 2000; Metaxiotis *et al.*, 2002a, b). The main categories analyzed herein are expert systems (ES), artificial neural networks (ANN) and intelligent agents (IA).

3.1 Expert systems

ES emerged, as a branch of AI, from the effort of AI researchers to develop computer programs that could reason as humans. Welbank (1983) defines an expert system as follows:

> An expert system is a program which has a wide base of knowledge in a restricted domain, and uses complex inferential reasoning to perform tasks which a human expert could do.

In other words, an ES is a computer system containing a well-organized body of knowledge that emulates expert problem solving skills in a bounded domain of expertise. The system is able to achieve expert levels of problem solving performance, which would normally be achieved by a skilled human when confronted with significant problems in the domain (BCS, Expert Systems Specialist Group).

As Hendriks and Vriens (1999) have stressed, the noun "knowledge" is common to both the KM and ES disciplines. The knowledge base is the heart of an ES and contains the knowledge needed for solving a specific problem. The knowledge may be in the form of facts, heuristics (e.g. experiences, opinions, judgments, predictions, algorithms) and relationships usually gleaned from the mind of experts – through specific knowledge acquisition methods (e.g. interviews, protocol analysis, questionnaires, card sorting, etc.) – in the relevant domain. In order to capture knowledge and develop knowledge repositories in KM systems for formally documenting knowledge in an on-line way, these knowledge acquisition techniques can be applied.

Knowledge in ES can be represented using a variety of representation techniques (e.g. semantic nets, frames, predicate logic), but the most commonly used technique is "if-then" rules, also known as production rules. The KM field can take advantage of these techniques and of the relative "lessons-learnt" (success stories and failures) and apply them to support the codification of the knowledge in the KM systems.

On the other hand, it has been argued that the classical rule-based expert systems rely on assumptions of certainty and rationality, which are oriented towards solutions based on best choice between clearly available alternatives (Fowler, 2000). This is in contrast with the domain of KM, which assumes a world based on uncertainty, subjective meaning and belief (represented in the concept of "tacit knowledge"). However, the authors believe that the use of fuzzy logic and the development of a fuzzy ES partly destroy this argument. If we would like to find the main drawbacks or limitations of the application of ES technology to the KM field, we should focus on the following issues:

- Expert systems are unable to respond to strange and vague questions, or to get vague answers.
- There are many difficulties in the maintenance and updating of the knowledge base (Davenport and Prusak, 1998).
- Expert systems can not learn automatically by experience.

- Expert systems can not break rules or interrupt the inference engine's reasoning procedure, under exceptional circumstances, in the way that humans can.

3.2 Artificial neural networks

ANN is an information processing technique based on the way biological nervous systems, such as the brain, process information. The fundamental concept of ANNs is the structure of the information processing system. Composed of a large number of highly interconnected processing units ("neurons") connected into networks, a neural network system uses the human-like technique of learning by example to resolve problems (Haykin, 1994; Fausset, 1994). Every neuron applies an input, activation and an output function to its net input (sum of weighted input signals) to calculate its output. The neural network is configured for a specific application, such as data classification or pattern recognition, through a learning process called "training". Just as in biological systems, learning involves adjustments to the synaptic connections that exist between the neurons. In other words, the "learnt" information is stored in the form of numerical values, called "weights", which are assigned to the connections among the processing units of the network.

This approach is seen to be completely different to that which is involved in ES, since there is no explicit knowledge base, only a set of empirically derived relationships between data. So, it can not be claimed that ANNs possess knowledge in a specific field. Their function is to provide a "black-box" transformation of input data to outputs, based on previous "learning experiences". The main advantage of this technology is that it can operate with incomplete data to generalize and demonstrate apparent intuition. In addition, ANNs appear to work more analogously to the brain, which has much potential within the KM framework. Also they are capable of profiling users to enable information to be targeted at specific individuals according to their preferences and interests. KM can take advantage of this technology in order to advance knowledge distribution and sharing. Instead of simply having a passive distribution mode where it is up to the individual to access the organization's knowledge repository, there may be a specific module (knowledge distributor) in charge of analyzing the knowledge and distributing it to the persons and stakeholders.

On the other hand, a drawback of ANN technology is the fact that ANNs ultimately need their inputs to be presented in numeric form so that they can then be subjected to the learnt weighting algorithms. This is in contrast to an ES, which also accepts symbolic inputs (object-oriented analysis) and of course this is in contrast with the domain of KM, which assumes a world, based on entities and practical meanings.

3.3. Intelligent agents

To answer the question "what is an intelligent agent?", we employ Jennings and Wooldridge's definition (Jennings and Wooldridge, 1998):

> An agent is a computer system situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives.

In general, agents are owners of a great amount of knowledge, professional experiences and beliefs that they use in order to accomplish their tasks. The study of intelligent agents has become one of the most important fields in distributed artificial intelligence (DAI) (Knapik and Johnson, 1997; Murch and Johnson, 1998; Wagner, 1998; Metaxiotis *et al.*, 2002c).

Intelligent agents differ from objects in a number of ways. Intelligent agents manipulate objects to perform their tasks (an intelligent agent may be thought of as an object with a head!). The behavior of intelligent agents (the tasks that they perform and how the tasks are performed) can be modified dynamically, due to learning or influence of other agents. Intelligent agents can be autonomous, can reason about themselves and can be mobile. They can actively and dynamically seek to cooperate to solve problems, using task and domain-level protocols (an important goal is convergence on solutions despite incomplete or inconsistent knowledge or data).

In this framework, intelligent agents can be used to help in the search and retrieval methods of knowledge in KM systems. In addition, they can be used very successfully to assist in combining knowledge, which would ultimately lead to the creation of new knowledge. Participating in various knowledge relationships, intelligent agents can create multiple perspectives of the same situation. These perspectives may contribute to enlarging the number of possible solutions, which improves the quality of the decision-making process (Carneiro, 2001). Moreover, intelligent agents could be applied to analyze knowledge and to disseminate suitable pieces of information and knowledge (e.g. summaries, recommendations, findings) to those who should make use of it. On the other hand, we should not underestimate the

fact that they do not necessarily overcome the problems inherently associated with the "knowledge bottleneck" phenomenon as presented in knowledge engineering.

4. Conclusions and future research

Nowadays it has become clear to many organizations that they need to manage knowledge-related activities in a systematic and explicit way in order to improve their competitive positions. Valuable human and knowledge resources will be wasted unless management openly accepts and supports efforts to gather, sort, transform, record and share knowledge. Knowledge management seems to be able to provide to decision makers enhanced quality of support in the direction of real-time adaptive active decision support. It should not be underestimated the fact that companies like General Electric, McKinsey & Company, Xerox, Microsoft, Ernst & Young and Accenture have already identified the benefits of KM and are included in the Top 20 Most Admired Knowledge Enterprises (2002 North American MAKE Award winners). In addition, the World Bank leverages global knowledge sharing to attain its goal of becoming a clearinghouse for expertise on sustainable development (Wah, 1999). The World Bank spends 4 per cent of its administrative budget on knowledge management and is spending over $50 million to build a global knowledge-management system (Isaacs, 1999).

However, organizations still need information technology, including surely aspects of AI, in order to facilitate and share knowledge. While it is clearly important to recognize the limitations of these technologies – especially with respect to the management of tacit knowledge – it is sure that they can play a supporting role in KM processes. It is our belief that there is still a need for deeper understanding of the use of AI in decision support through knowledge management. The key research issue is the development of an integrated framework for the use of AI technologies in various KM processes. Another research challenge is to assess the level of AI currently employed in KM applications in a qualitative way. Yet a third important challenge is to develop methods to measure KM benefits from the use of various information technologies.

Finally, the authors strongly believe that the creation of hybrid systems (e.g. combination of ES and ANN) can offer access to embedded knowledge coupled with an ability to function in the partial absence of certain data. Such systems may also exhibit a capacity to learn and improve their performance over time.

References

Basu, A. (1998), "Perspectives on operations research in data and knowledge management", *European Journal of Operational Research*, Vol. 111 No. 1, pp. 1-14.

Bollinger, A. and Smith, R. (2001), "Managing organizational knowledge as a strategic asset", *Journal of Knowledge Management*, Vol. 5 No. 1, pp. 8-18.

Bolloju, N., Khalifa, M. and Turban, E. (2002), "Integrating knowledge management into enterprise environments for the next generation decision support", *Decision Support Systems*, Vol. 33 No. 2, pp. 163-76.

Carneiro, A. (2001), "The role of intelligent resources in knowledge management", *Journal of Knowledge Management*, Vol. 5 No. 4, pp. 358-67.

Davenport, T. and Prusak, L. (1998), *Working Knowledge: Managing What Your Organisation Knows*, Harvard Business School Press, Boston, MA.

Davenport, T., DeLong, D. and Beers, M. (1998), "Successful knowledge management projects", *Sloan Management Review*, Vol. 39 No. 2, pp. 43-57.

Drucker, P. (1993), *Post Capitalist Society*, Harper Row, New York, NY.

Fausett, L. (1994), *Fundamentals of Neural Networks. Architectures, Algorithms and Applications*, Prentice-Hall, Englewood Cliffs, NJ.

Fowler, A. (2000), "The role of AI-based technology in support of the knowledge management value activity cycle", *Journal of Strategic Information Systems*, Vol. 9 No. 2/3, pp. 107-28.

Galagan, P. (1997), "Smart companies (knowledge management)", *Training and Development*, Vol. 51 No. 12, pp. 20-5.

Haykin, S. (1994), *Neural Networks: A Comprehensive Foundation*, Macmillan, Basingstoke.

Hendriks, P. and Vriens, D. (1999), "Knowledge based systems and knowledge management: friends or foes", *Information and Management*, Vol. 35 No. 2, pp. 113-25.

Holsapple, C. and Joshi, K. (1997), "Knowledge management: a three-fold framework", *Kentucky Initiative for Knowledge Management*, No. 104.

IDC (2002), "Knowledge management study", *eINFORM*, Vol. 3 No. 8.

Isaacs, W. (1999), *Dialog and the Art of Thinking Together*, Currency/DoubleDay, New York, NY.

Jennings, N.R. and Wooldridge, M.J. (Eds) (1998), *Agent Technology: Foundations, Applications, and Markets*, Springer Verlag, Berlin.

Knapik, M. and Johnson, J. (1997), *Developing Intelligent Agents for Distributed Systems:*

Exploring Architecture, Technologies and Applications, McGraw-Hill, New York, NY.

Leonard, D. (1999), *Wellsprings of Knowledge – Building and Sustaining the Sources of Innovation*, Harvard Business School Press, Boston, MA.

Liebowitz, J. (1997), "Knowledge-based/expert systems technology in life support systems", *Kybernetes*, Vol. 26 No. 5, pp. 555-73.

Liebowitz, J. (2000), *Building Organizational Intelligence: A Knowledge Management Primer*, CRC Press, Boca Raton, FL.

Mentzer, J. and Gandhi, N. (1993), "Expert system in industrial marketing", *Industrial Marketing Management*, Vol. 22 No. 2, pp. 109-16.

Merlyn, P. and Valikangas, L. (1998), "From information technology to knowledge technology: taking the user into consideration", *Journal of Knowledge Management*, Vol. 2 No. 2, pp. 28-35.

Metaxiotis, K. and Samouilidis, J.-E. (2000), "Expert systems in medicine: academic illusion or real power?", *Information Management & Computer Security*, Vol. 8 No. 2, pp. 75-9.

Metaxiotis, K., Askounis, D. and Psarras, J. (2002a), "Expert systems in production planning and scheduling: a state-of-the-art survey", *Journal of Intelligent Manufacturing*, Vol. 13 No. 4, pp. 253-60.

Metaxiotis, K., Samouilidis, E. and Psarras, J. (2002b), "Artificial intelligence in production scheduling: two decades of research and promises", invited paper, International Symposium for Scheduling 2002, CUREAC, Lake Hamanako, 3-6 June.

Metaxiotis, K., Psarras, J. and Papastefanatos, S. (2002c), "Knowledge and information management in e-learning environments: the user agent architecture", *Information Management & Computer Security*, Vol. 10 No. 4, pp. 165-70.

Murch, R. and Johnson, T. (1998), *Intelligent Software Agents*, Prentice-Hall, Ottawa.

Nonaka, I. (1991), "The knowledge-creating company", *Harvard Business Review*, Vol. 69, November-December, pp. 96-104.

Nonaka, I. (1994), "A dynamic theory of organizational knowledge creation", *Organization Science*, Vol. 5 No. 1, pp. 14-37.

Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McGaw, D., Newman, B. and Rebeck, K. (2001), "SMARTVision: a knowledge-management methodology", *Journal of Knowledge Management*, Vol. 5 No. 4, pp. 300-10.

Senge, P. (1990), *The Fifth Discipline: The Art and Practice of the Learning Organisation*, Doubleday, New York, NY.

Tafti, M. and Nikbakht, E. (1993), "Neural networks and expert systems: new horizons in business finance applications", *Information Management & Computer Security*, Vol. 1 No. 1. pp. 22-8.

Wagner, G. (1998), *Foundations of Knowledge Systems: With Applications to Databases and Agents*, Kluwer Academic, Boston, MA.

Wah, L. (1999), "Behind the buzz", *Management Review*, Vol. 88 No. 4, pp. 17-26.

Welbank, M. (1983), *A Review of Knowledge Acquisition Techniques for Expert Systems*, British Telecommunications Research Laboratories, Technical Report, Ipswich.

Wiig, K. (1993), *Knowledge Management Foundations: Thinking about Thinking – How People and Organizations Create, Represent and Use Knowledge*, Schema Press, Arlington, TX.

Wiig, K. (1997), "Knowledge management: where did it come from and where will it go?", *Expert Systems With Applications*, Vol. 13 No. 1, pp. 1-14.

Wiig, K. (1999), "What future knowledge management users may expect", *Journal of Knowledge Management*, Vol. 3 No. 2, pp. 155-65.

Wiig, K., de Hoog, R. and van der Spek, R. (1997), "Supporting knowledge management: a selection of methods and techniques", *Expert Systems with Applications*, Vol. 13 No. 1, pp. 15-27.

Wilkins, J., Van Wegen, B. and De Hoog, R. (1997), "Understanding and valuing knowledge assets: overview and method", *Expert Systems with Applications*, Vol. 13 No. 1, pp. 55-72.

Zeleny, M. (2000), "Knowledge vs. information", *The IEBM Handbook of Information Technology in Business*, Thomson Learning, London, pp. 162-8.

Zhang, G., Patuwo, B. and Hu, M. (1998), "Forecasting with artificial neural networks: the state of the art", *International Journal of Forecasting*, Vol. 14 No. 1, pp. 35-62.

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Bichindaritz, I. and Sullivan, K. (1998), *Roles for Agent Technology in Knowledge Management: Examples from Applications in Aerospace and Medicine*, White Paper, Boeing Information and Support Services, Seattle, WA.

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